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(54) **Heat and moisture exchange devices.**

(57) A heat and moisture exchanger has an element 4 formed by a strip of bacterial filter material that is folded laterally into pleats and bent into a loop so that the folds 41 and 42 extend radially. The element 4 is sealed around its outer edge into a circular casing 1 having axial, tapered ports 2 and 3 at opposite end. A conical gas diverter 46 and 47 is sealed into a central opening of the element 4 on each side. Exhaled gas warms and moistens the element 4; inhaled gas is filtered and takes up some of the heat and moisture from the element. The exchanger is symmetrical so that it can be used either way around.

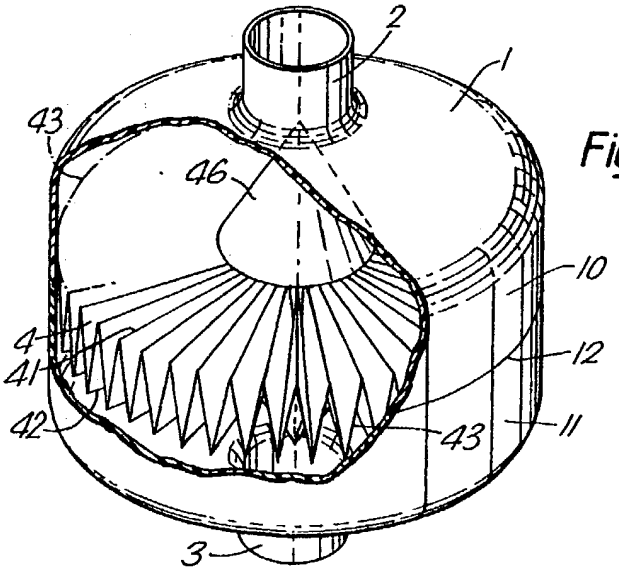

Fig.1.

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HEAT AND MOISTURE EXCHANGE DEVICES

This invention relates to heat and moisture exchange devices of the kind for transferring heat and moisture in exhaled respiratory gas to inhaled respiratory gas including an outer casing and an exchange element within the outer casing.

Heat and moisture exchange devices are used in medico-surgical applications to take up heat and moisture from a patient's exhaled breath passing through the device and to transfer it to inhaled gas. One disadvantage with the presently available exchange devices, is that they impede the flow of the gas, leading to a pressure drop across the exchange element. This pressure drop can be reduced by increasing the area of the element exposed to the gas. This, however, makes the element larger and heavier, thereby correspondingly increasing the size and weight of the housing which may cause discomfort to the patient. It can also increase the dead space within the casing and increases the cost of the device itself, its packaging, transport and storage. Some devices must be connected in a particular orientation in order to prevent the build up of condensation in the device. This is a disadvantage because it requires care to be taken by the user in connecting the device into the patient breathing circuit.

It is an object of the present invention to provide a heat and moisture exchange device that can be used to alleviate the above-mentioned problems.

According to one aspect of the present invention there is provided a heat and moisture exchange device of the above-specified kind, characterised in that the exchange element comprises a strip of material folded into a plurality of pleats laterally of the length of the strip, and that the strip is bent into a loop such that the folds of the pleats extend radially of the loop in two parallel planes substantially normal to the direction of flow of respiratory gases through the element.

The opposite ends of the strip are preferably joined together. The loop may have a central opening with a gas diverter mounted therein to divert gas onto the exchange element. The exchange element is preferably sealed around its outer edge in the casing by a settable sealing compound. The outer casing may be of circular section, the exchange element being located axially within the casing with the planes of the folds of the pleats extending transversely of the casing, and the casing having a first port arranged axially on one side of the element and a second port arranged axially on the other side of the element. The casing may have a tapered port at each end which communicates with a respective side of the exchange element.

The exchange element is preferably made of a filter material, the exchange element being arranged in the casing such that gas flowing through the device is filtered. The filter material is preferably a bacterial filter material.

According to another aspect of the present invention there is provide a method of making a heat and moisture exchange device, characterised in that the method comprises comprising the steps of: folding a strip of material laterally at equal intervals in opposite senses to form pleats; compressing the pleats into a pack such that adjacent pleats contact one another, the pack having two opposite faces between which the folds of the pack extend; sealing together adjacent pleats on one face; pulling opposite end folds of the pack from adjacent the other face around the one face to form a loop with the folds of the pleats extending radially; joining the opposite end folds together; filling any space at the centre of the loop; inserting the loop into a casing; and sealing the outer edge formed by the other face of the pack with the inside of the casing such that exhaled warm, moist gas flowing through the device in one direction flows through the material and a part of the heat and moisture is retained by the material, whereas inhaled gas flows through the material in the opposite direction and is warmed and moistened by the retained heat and moisture.

The adjacent pleats on the one face are preferably sealed together by coating the one face with a flexible, settable sealing compound.

A heat and moisture exchange device for medical ventilation gases, and its method of manufacture, in accordance with the present invention, will now be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 is a perspective view of the exchange device;

Figure 2 is a sectional side elevation view of the exchange device; and

Figures 3 to 6 illustrate steps in the manufacture of a part of the exchange element.

The heat and moisture exchange device comprises a moulded plastics casing 1 with an inlet port 2 and an outlet port 3, the casing containing an exchange element 4.

The casing 1 is moulded in two parts 10 and 11, from a hard plastics material such as nylon or PVC, which are joined together along a circumferential split line 12. The casing 1 is of cylindrical shape and circular section with the inlet 2 and outlet 3 located axially in line which communicate with opposite sides of the element 4. The inlet 2

and outlet 3 are conventional luer taper or anaesthetic taper fittings and may be male, female or of a universal form incorporating a coaxial arrangement of a male and female coupling.

The exchange element 4 is made of a high efficiency, bacterial filtration medium such as a glass fibre membrane treated with a silicone oil, such as Syloff AVA sold by the Whatman Paper Company.

The exchange element 4 takes up heat and moisture in exhaled breath passing through the element 4 and transfers it to gas passing through the element in the opposite direction. The element 4 is permeable to gases but impermeable to bacteria and viral particles either by sieving these bacteria and particles from the gas stream or by providing a tortuous path through the element which causes these and other particles to be impeded upon the surface of the element because their greater momentum prevents them from circumnavigating the fibres of the element. In this respect, the element also acts as a filter as well as a heat and moisture exchange element.

The element 4 is in the form of a pleated circular loop of filter material with the folds 41 and 42 of the pleats extending radially. The folds 41 lie in a plane transverse to the direction of flow through the device as indicated by the arrows F; the opposite folds 42 lie in a plane parallel to that including the folds 41 but located closer to the outlet 3 of the device. The outer edge 43 of the exchange element 4 is sealed to the inner surface of the casing 1 such that there is no path for gas flow between the exchange element and the casing. In this respect, an adhesive or settable sealing compound can be used.

The inner edge 44 of the exchange element 4 is sealed, with an adhesive or settable sealing compound, to a gas-impermeable core piece 45 which extends through the centre of the element and blocks passage of gas through the centre. The core piece 45 is a hollow moulding of a light plastics material which is cylindrical in shape and provided with two flow diverters 46 and 47 at opposite ends. Both diverters 46 and 47 are of conical shape with a base that overlaps the inner edge 44 of the upper and lower surface of the exchange element 4. The exchange device is, therefore, of symmetrical configuration. Instead of using a gas-impermeable core piece, this could be replaced with an element having filtering and heat and moisture exchange properties similar to those of the glass fibre membrane.

In use, the inlet 2 is connected to a ventilation circuit which may include ventilation or anaesthetic equipment or may simply be open to atmosphere. The lower outlet 3 is connected via tubing to a tracheal tube or breathing mask. When the patient inhales, gas enters the device in a downwardly direction (although the device can be used in any orientation) through the inlet 2 and is diverted radially outwardly by the upper diverter 46 onto the upper surface of the element 4. Pressure difference across the element 4 causes gas to flow through the inclined faces of the element between the folds 41 and 42 of the pleats. Gas passing through the exchange element 4 flows out of the device through the outlet 3. When the patient exhales, gas flows through the device in the opposite direction, from the outlet to the inlet.

By mounting a diverter 46 and 47 on both sides of the filter element 4 it enables the device to be used either way around, providing that the inlet and outlet couplings 2 and 3 are compatible with the connections to the device. This is an advantage because it means that no special care need be taken to ensure that the device is correctly oriented.

The exchange element 4 is preferably made in the manner shown in Figure 3 to 6. First, as shown in Figure 3, a strip of the filter material, which is typically 21mm wide and 2857mm long, is folded laterally at equal intervals in opposite senses to form fifty-one pleats each of length 56mm. The strip is then compressed into a pack so that adjacent pleats come into contact with one another in the manner shown in Figure 4. Next, the pleats on one face of the pack, which will eventually form the inner edge 44 of the exchange element 4, are sealed by coating the face with a flexible, settable sealing compound 50, as shown in Figure 5. The opposite end folds of the pack are then gripped close to the opposite face and pulled around, as shown in Figure 6, to form a loop. An adhesive is used to seal these end folds together. The element now formed resembles a ruff with the folds 41 and 42 of the pleats extending radially and with an outer diameter of 56mm, an inner diameter of 14mm and a thickness of 27mm. Prior to installation in the casing 1, the outer edge 43 of the element is sealed and coated with a similar compound to that applied to the inner edge 44. The element 4 is preferably installed in the casing 1 before the sealing compound is set, so that it conforms to the inner surface of the casing 1 and seals with it. The core piece 45 with the flow diverters 46 and 47 are mounted on the exchange element 4 before installation in the casing.

Because the folds 41 and 42 of the exchange element 4 extend radially, the average separation between the pleats is greater than in previous exchange elements employing axially arranged pleats. This gives the device a more open construction thereby admitting more gas to the element which in turn allows more gas to pass through the entire element and reduces the resis-

tance to flow provided by the element. In this way, the size of element can be smaller than that of a conventional exchange element having the same resistance to flow. The exchange device of the present invention can, therefore, be made smaller and lighter than previous device or with reduced resistance to flow.

Claims

1. A heat and moisture exchange device for transferring heat and moisture in exhaled respiratory gas to inhaled respiratory gas including an outer casing, and an exchange element within the casing, characterised in that the exchange element (4) comprises a strip of material folded into a plurality of pleats laterally of the length of the strip, and that the strip is bent into a loop such that the folds (41, 42) of the pleats extend radially of the loop in two parallel planes substantially normal to the direction of flow of respiratory gases through the element (4).

2. A device according to Claim 1, characterised in that the opposite ends of the strip are joined together.

3. A device according to Claim 1 or 2, characterised in that the loop has a central opening (44) with a gas diverter (45, 46, 47) mounted therein to divert gas onto the exchange element (4).

4. A device according to any one of the preceding claims, characterised in that the exchange element (4) is sealed around its outer edge (43) in the casing (1) by a settable sealing compound.

5. A device according to any one of the preceding claims, characterised in that the outer casing (1) is of circular section, that the exchange element (4) is located axially within the casing (1) with the planes of the folds (41, 42) of the pleats extending transversely of the casing (1), and that the casing (1) has a first port (2) arranged axially on one side of the element and a second port (3) arranged axially on the other side of the element.

6. A device according to any one of the preceding claims, characterised in that the casing (1) has a tapered port (2, 3) at each end which communicates with a respective side of the exchange element (4).

7. A device according to any one of the preceding claims, characterised in that the exchange element (4) is made of a filter material, and that the exchange element is arranged in the casing such that gas flowing through the device is filtered.

8. A device according to Claim 7, characterised in that the filter material is a bacterial filter material.

9. A method of making a heat and moisture exchange device, characterised in that the method comprises comprising the steps of: folding a strip of material laterally at equal intervals in opposite senses to form pleats; compressing the pleats into a pack such that adjacent pleats contact one another, the pack having two opposite faces (43 and 44) between which the folds (41 and 42) of the pack extend; sealing together adjacent pleats on one face (44); pulling opposite end folds of the pack from adjacent the other face (43) around the one face (44) to form a loop with the folds (41 and 42) of the pleats extending radially; joining the opposite end folds together; filling any space at the centre of the loop; inserting the loop into a casing (1); and sealing the outer edge (43) formed by the other face of the pack with the inside of the casing (1) such that exhaled warm, moist gas flowing through the device in one direction flows through the material and a part of the heat and moisture is retained by the material, whereas inhaled gas flows through the material in the opposite direction and is warmed and moistened by the retained heat and moisture.

10. A method according to Claim 9, characterised in that the adjacent pleats on the one face (44) are sealed together by coating the one face with a flexible, settable sealing compound (50).

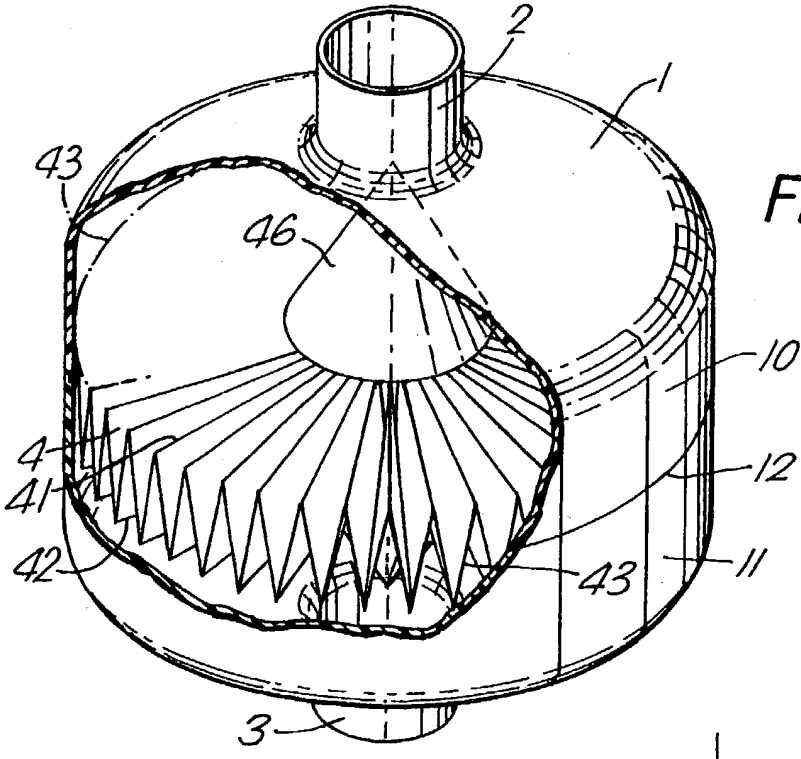
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Fig.1.

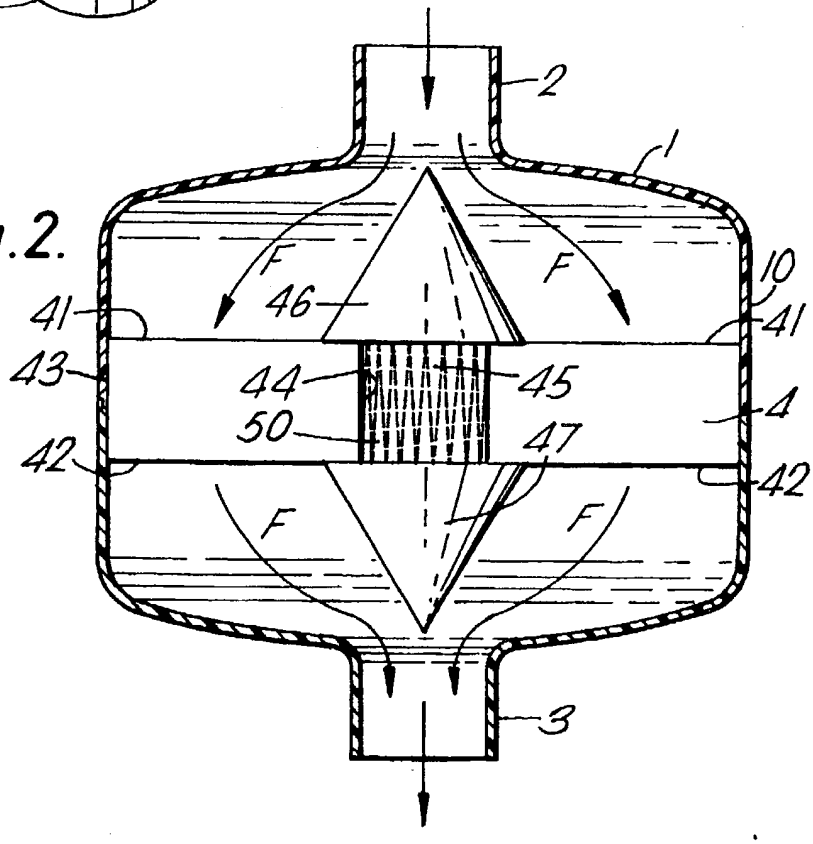
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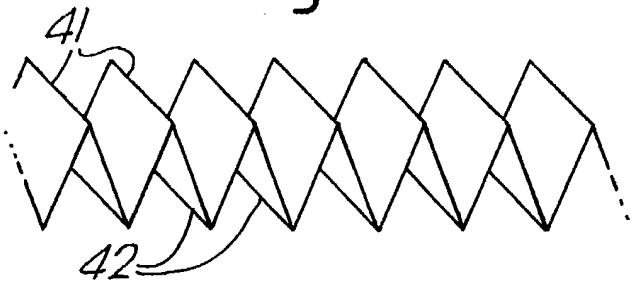
Fig.2.

Fig.3.



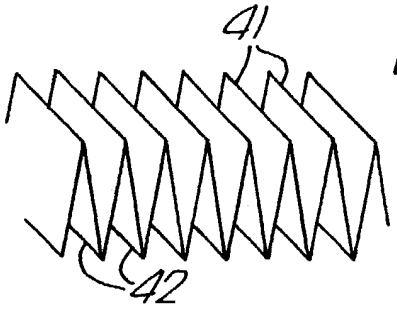


Fig.4.

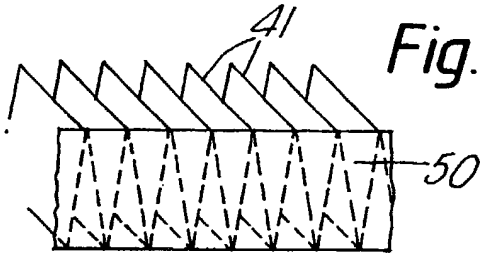


Fig.5.

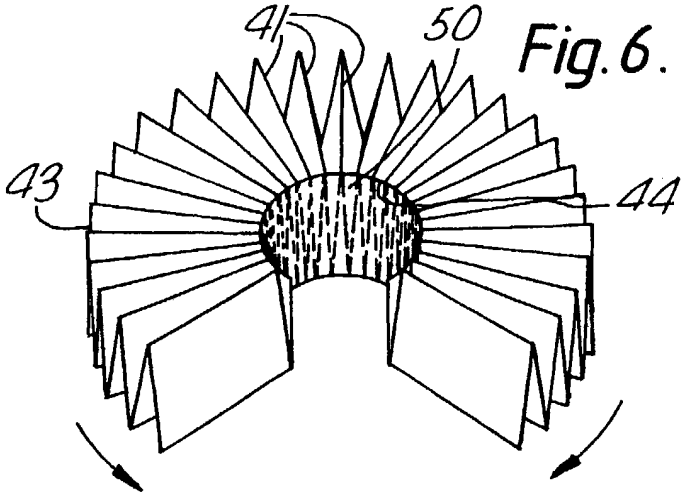


Fig.6.

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EUROPEAN SEARCH REPORT

Application Number

EP 90 30 6397

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	EP-A-0 205 072 (TERUMO K.K.) * Claims *	1	A 61 M 16/00 B 01 D 46/52
Y	US-A-3 803 817 (R.D. LEWIS) * Drawings; column 2, line 20 - column 4, line 25 *	1	
A		2,3,4,5,7,9,10	
A	US-A-4 619 675 (M. WATANABE) * Column 2, line 12 - column 3, line 11; drawings *	1,2,4,5,7	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

A 61 M
B 01 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	17-10-1990	BOGAERTS M.L.M.

CATEGORY OF CITED DOCUMENTS

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